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IS 2122-1 (1973): Code of practice for selection, storage, installation and maintenance of belting for power transmission, Part I: Flat belt drives [PGD 31: Bolts, Nuts and Fasteners Accessories]



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Indian Standard

CODE OF PRACTICE FOR SELECTION, STORAGE, INSTALLATION AND MAINTENANCE OF BELTING FOR POWER TRANSMISSION

PART I FLAT BELT DRIVES

(First Revision)

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**BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002**

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June 1974

Indian Standard

**CODE OF PRACTICE FOR
SELECTION, STORAGE, INSTALLATION
AND MAINTENANCE OF BELTING
FOR POWER TRANSMISSION**

PART I FLAT BELT DRIVES

(First Revision)

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CODE OF PRACTICE FOR SELECTION, STORAGE, INSTALLATION AND MAINTENANCE OF BELTING FOR POWER TRANSMISSION

PART I FLAT BELT DRIVES

(First Revision)

0. FOREWORD

0.1 This Indian Standard (Part I) (First Revision) was adopted by the Indian Standards Institution on 14 December 1973, after the draft finalized by the Pulleys and Belts Sectional Committee had been approved by the Mechanical Engineering Division Council.

0.2 There are various types of drives used for power transmission in the engineering industry. This code relates to belt drives. The purpose of this code is to unify the diverse practices prevalent for the selection, storage, installation and maintenance of belt drives.

0.3 While taking up the revision of the original standard which covered only flat belt drives, it was decided to take into its purview the V-belt drives also. As such, the code is being published in two parts, namely:

Part I Flat belts, and

Part II V-belts.

0.4 Selection of belt drives for power transmission depends on a number of design factors and service conditions. It is hoped that the information contained in this code in regard to the selection of drives of the choice of belt would be of assistance to the users of belt drives.

0.5 A list of relevant standards pertaining to allied items is included in Appendix A for ready reference of the user.

0.6 Where the provisions of this standard conflict with a statutory requirements the latter shall prevail.

1. SCOPE

1.1 This standard (Part I) covers the requirements for selection, storage, installation and maintenance of flat belt drives for power transmission.

2. SELECTION OF DRIVE

2.1 Selection of a belt drive is normally based on factors like the space available, power to be transmitted, speed of the driver and the driven shafts, and the service conditions.

3. CHOICE OF BELT

3.1 When selecting the belt for a drive, it is always desirable to make use of the recommendations of the manufacturer.

3.1.1 The relevant Indian Standards are listed in Appendix A.

4. DRIVE LAYOUT

4.1 **Horizontal Drive** — There is an almost infinite range of variations possible in drive layout. The simplest drive is where the centres are horizontal as shown in Fig. 1. This drive could be laid out with the slack side either at the top or below the centres. Slack on the top has the advantage of effectively increasing the contact made by the belt with the pulley due to the sag, and, therefore, increasing the drive efficiency.

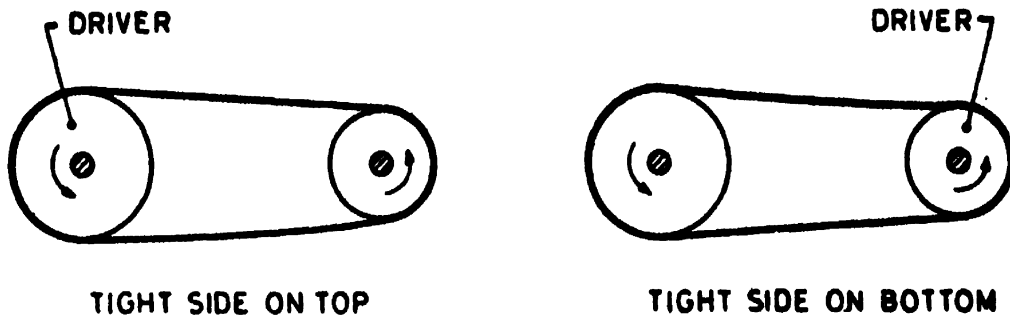


FIG. 1 HORIZONTAL DRIVE

4.2 **Vertical Drive** — Wherever operating conditions permit, vertical drives should be avoided. Due to the force of gravity and to the fact that the pulleys are one above the other, the natural tendency is for the belt to fall away from the lower pulley surface. This causes slip apart from reducing the driving efficiency. To run such a drive, the belt has either to be run at excessive tension with consequent strain on the bearings or a belt with a much larger cross-sectional area than is normally used, has to be installed.

4.2.1 The majority of drives, therefore, operate at an angle, that is where the straight line connecting the two shafts is between the horizontal and vertical planes.

4.3 Special Drives — The relative position of the driver and the driven equipment very often determines that other types of layout have to be devised than those described above. A short description of these special drives is given below.

4.3.1 Quarter-Turn Drive — This is a drive in which the plane corresponding to the edge of one pulley is perpendicular to the plane corresponding to the edge of second pulley. Also, a plane passing through the centre of the face of any pulley and parallel to its edge, should be tangential to the face of the other pulley (*see* Fig. 2).

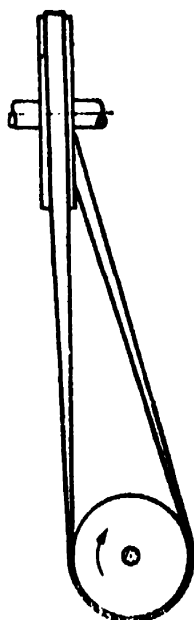


FIG. 2 QUARTER-TURN DRIVE

4.3.2 Crossed-Drive — This type of drive is used only where the pulleys are to rotate in opposite directions (*see* Fig. 3). The width of the belt is very important. A fairly narrow belt should be used as otherwise there is considerable strain on the belt due to the turning over on both the slack and tight sides. — On short-centre drives, the contact of the belt on the face of the pulleys will not be perfect. Special care has to be taken in fixing fasteners if the belt is not endless as a protruding fastener is liable to rip the other section of the belt in brushing past it.

4.3.3 Cone-Drive — This type is normally used on machines where the speed ratio has to be constantly changed (*see* Fig. 4). Stepped pulleys may be used in place of cones in which case the speed ratios are limited by the number of steps, the belt being specially mounted for each speed change (*see* Fig. 5).

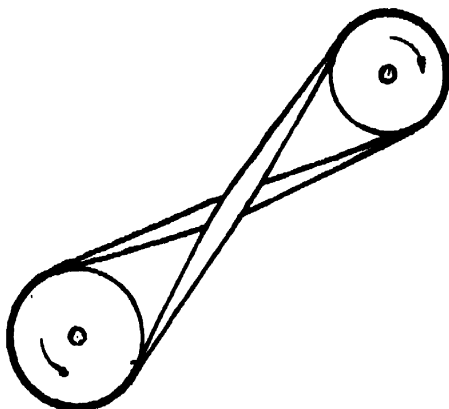


FIG. 3 CROSSED-DRIVE

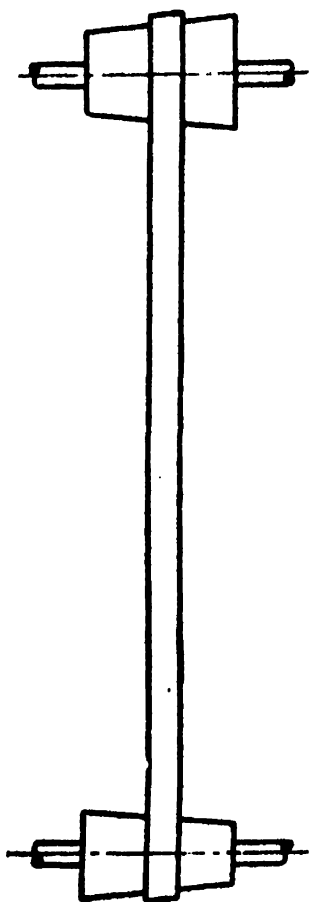


FIG. 4 CONE-DRIVE

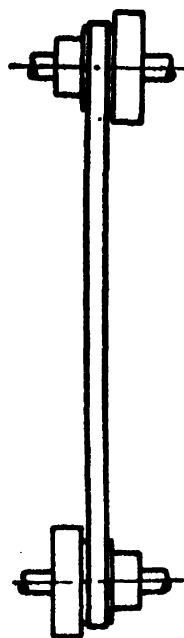


FIG. 5 STEPPED-PULLEY DRIVE

4.3.4 Jockey-Pulley Drive — This is the standard method of increasing the arc of contact on the small pulley where the speed ratio is high and the centre distance low (*see* Fig. 6). It is also used where the drive is not provided with a take-up for adjusting the stretch in the belt. A variation of this drive is the 'pulmax' or 'lenix' drive (*see* Fig. 7), where by the

use of a weighted or spring-loaded idler, the advantage of increased arc of contact is retained whilst the amount of tension in the belt is controlled.

4.3.5 Fast and Loose Pulley Drives — These drives (see Fig. 8) are generally used in conjunction with line shafts so that any machine being driven through the line shaft can be stopped without stopping the line shaft. Narrow belts are generally used for ease in shifting. Special attention has to be paid to the bearings to ensure free running of the loose pulley.

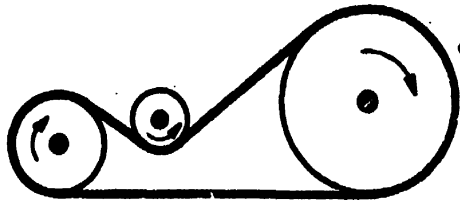


FIG. 6 JOCKEY-PULLEY DRIVE

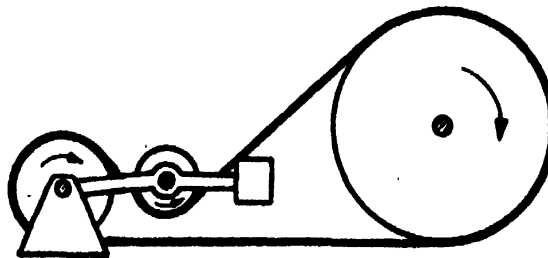


FIG. 7 PULMAX OR LENIX DRIVE

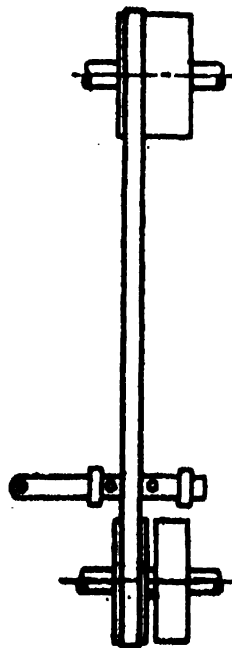
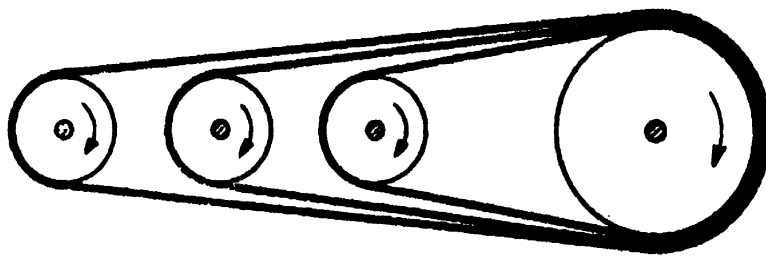


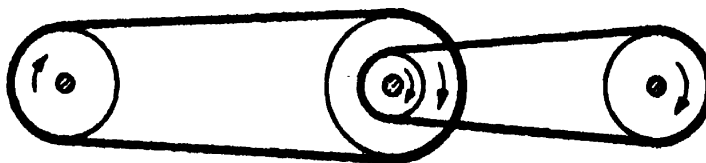
FIG. 8 FAST AND LOOSE PULLEY DRIVE

It has been found that by using a loose pulley of a slightly lesser diameter than the fast pulley, the tension on the belt and the bearings is considerably reduced while idling. In such cases, a bevelled edge is required on the larger driving pulley to permit the belt to climb up on to it when shifted. Roller type belt shifters are preferable to forks as they reduce edge wear on the belt.

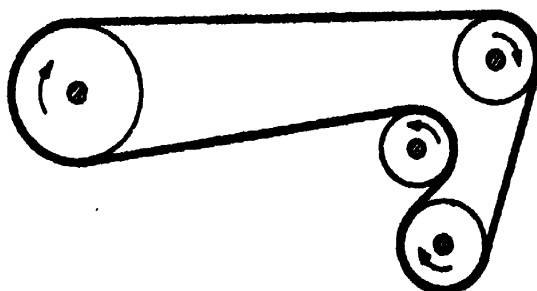
4.3.6 Compound Drives — Also called serpentine drives; are used where one driving pulley drives a number of different shafts at varying speeds (see Fig. 9). In such cases, the belt very often has to drive from both the sides and hence it is recommended that an endless belt or the belt spliced endless should be used.



MULTI-PULLEY COMPOUND DRIVE



SERIES DRIVE



MULTIPLE DRIVE

FIG. 9 COMPOUND DRIVES

4.3.7 Right-Angled Drive — Sometime the power is required at right angle to the prime mover. In such cases a right-angled drive is used (see Fig. 10). For such drives, the fasteners should be carefully fitted as detailed in 9.

4.3.8 For a short centered drive, a reverse drive (Fig. 11) is recommended in preference to a crossed drive (Fig. 3).

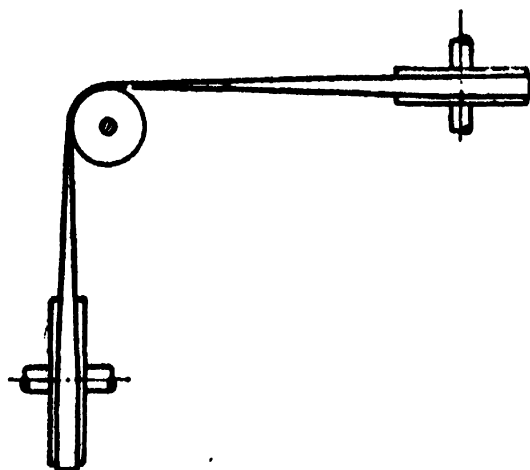


FIG. 10 RIGHT-ANGLED DRIVE



FIG. 11 REVERSE DRIVE

5. DESIGN OF BELT DRIVES

5.1 Pulleys — The higher the belt speed up to 30 m/s, the greater the power the same belt can transmit. The use of large diameter pulleys with increased belt speeds and power capacities also guards against the effect of excessive stresses on the top surface and uneven distribution of the load throughout the cross section of the belt, which occurs when it is flexed over small diameter pulleys.

5.2 Belts — The internal friction caused by flexing a thick belt over a small pulley reduces the life of the belt. When a drive is operated at high speeds, it is preferable, therefore, to design a thin and wide belt rather than a thick, narrow one.

5.2.1 A thin belt, being more flexible, hugs the pulleys and so increases the area of contact. A wide belt has more area in contact with pulleys, hence has a better grip.

5.2.2 There are three main exceptions to the general rule of wide and thin belts, namely, the following:

- a) Where guide forks or belt shifters are used a thin, wide belt offers more resistance to side shifting, and has a tendency to curl up at the edge of the guide fork;
- b) In the case of quarter-turn drives; a narrow, thick belt gives better results than a thin, wide one; and
- c) In the case of step-cone pulleys, a narrow and thick belt gives better results.

5.3 Pulley Widths — To obtain best working results, the pulleys should be wider than the belts by amounts shown below:

<i>Belt Width</i>	<i>Pulleys to be Wider Than the Belt Width by</i>
mm	mm
Up to and including 125	13
From 125 up to and including 250	25
From 250 up to and including 375	38
From 375 up to and including 500	50

5.4 Pulley Centres — Belt life may be measured in terms of the number of times the belt surface comes into contact with the pulley surface while transmitting the load. Consequently, within the limits set by the tendency of the belt to sag as a result of its own weight, the longer the pulley centre distance, proportionately longer the belt life.

5.4.1 In the case of crossed drives, a fairly long centre distance is essential as otherwise there will not be proper contact of the driving surface of the belt with the face of the pulleys.

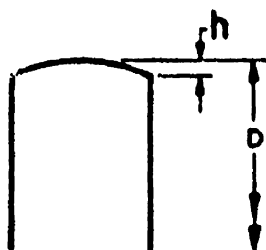
5.4.2 Provisions should also be made for the adjustment of the centre distance to take up slack that will accrue when the belt is put into service. Otherwise the belt will have to be cut frequently as it stretches, and will have to be rejoined (*see 6.3.2*). In case where no provision for the adjustment of the centre distance between the pulleys is possible, a loaded jockey-pulley may be used in the drive to take up the belt stretch.

5.5 Use of Crowned Pulleys — Pulleys should be crowned or cambered to compensate for slight misalignment thus ensuring that the belt rides centrally. If the pulleys are excessively cambered, the belt in time acquires a glazed surface in the centre as a result of carrying the whole load and slipping because the edges of the belt are not in contact with the pulley. Tables 1 and 2 give the values of crown for different diameters in accordance with IS: 1691-1968*.

TABLE 1 CROWN OF PULLEYS OF DIAMETERS FROM 40 mm TO 355 mm INCLUSIVE

(Crown is unrelated to the width in this diameter range)

All dimensions in millimetres.



DIAMETER D	CROWN h
40 to 112	0.3
125 and 140	0.4
160 and 180	0.5
200 and 224	0.6
250 and 280	0.8
315 and 355	1.0

NOTE — In the case of 140 mm diameter pulley, used for the railway train-lighting dynamo drive, in order to ensure that the belt rides centrally and to compensate for slight misalignment, while negotiating curves, the crown at present used is 3.2 mm.

5.5.1 In the case of drives with fast and loose pulleys, the driving pulley should have a perfectly flat face equal in width to the sum of the widths of faces of the driven pulleys. The loose pulley should have a flat surface and the fast pulley should have a cambered surfaces.

*Specification for cast iron and mild steel flat pulleys (first revision).

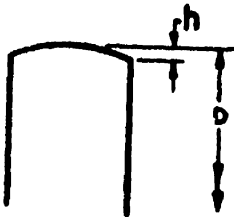
5.5.2 The pulley surface should be smooth giving complete contact, with a reasonable coefficient of friction, and minimum wear to the driving face of the belt. Rough surfaces which might give a higher coefficient of friction are to be avoided as they will reduce belt life.

TABLE 2 CROWN OF PULLEYS OF DIAMETERS FROM 400 mm TO 2 000 mm

(Crown varies with the width in this diameter range)

(Clause 5.5)

All dimensions in millimetres.



DIAMETER <i>D</i>	CROWN <i>h</i> OF PULLEYS OF WIDTH						
	125 and Smaller	140 and 160	180 and 200	224 and 250	280 and 315	335	400 and Larger
400	1·0	1·2	1·2	1·2	1·2	1·2	1·2
450	1·0	1·2	1·2	1·2	1·2	1·2	1·2
500	1·0	1·5	1·5	1·5	1·5	1·5	1·5
560	1·0	1·5	1·5	1·5	1·5	1·5	1·5
630	1·0	1·2	2·0	2·0	2·0	2·0	2·0
710	1·0	1·5	2·0	2·0	2·0	2·0	2·0
800	1·0	1·5	2·0	2·5	2·5	2·5	2·5
900	1·0	1·5	2·0	2·5	2·5	2·5	2·5
1 000	1·0	1·5	2·0	2·5	3·0	3·0	3·0
1 120	1·2	1·5	2·0	2·5	3·0	3·0	3·5
1 250	1·2	1·5	2·0	2·5	3·0	3·5	4·0
1 400	1·5	2·0	2·5	3·0	3·5	4·0	4·0
1 600	1·5	2·0	2·5	3·0	3·5	4·0	5·0
1 800	2·0	2·5	3·0	3·5	4·0	5·0	5·0
2 000	2·0	2·5	3·0	3·5	4·0	5·0	6·0

6. INSTALLATION OF BELT DRIVES

6.1 Flat transmission belts should never be prised on the pulleys. Particularly in the case of thick belts the edge can be irretrievably damaged by this means before it has carried any load.

6.1.1 Where a take-up adjustment exists, the pulley centres should be reduced to their minimum and the belt fitted by hand. Where there is no adjustment permitting the taking up of slack to apply initial tension, the belt should be fitted by means of a stretcher. It is important that the stretcher jaws should not be allowed to slip as they may cause serious damage to the surface of the belt.

6.1.2 It is essential that the two ends of the belt, making the joint, whether it is spliced endless or fixed with fasteners, should be cut square, so that the joined belt can run straight and free on the pulleys. Generally, one of the commonest causes of trouble is the failure to check the squareness of the belt ends before making a joint. The belt may run off the pulleys. There may be severe edge wear and a tendency for the fasteners to pull out of what is in effect the shorter side of the belt.

6.1.3 Where the belt shows a sign of edge wear and the fastener shows a sign of pull out and the belt does not actually run off the pulleys, the fact that an imperfect joint is the true cause of the trouble can be established by removing the belt and fitting it on the pulleys the other way round so that the right side becomes the left side and *vice versa*.

6.2 The pulleys should be aligned with their crowns centrally placed. Pulley camber crowns out of alignment, can result in the belt leaving the pulleys. In the installation of the numerous different types of drives other than the usual two-pulley, open or crossed drives, the alignment of the pulley shafts and driving faces is particularly important.

6.2.1 In a quarter-turn drive, a line parallel to the edges of one pulley and centrally placed with respect to its face, should pass parallel and centrally across the face of the other pulley in the drive.

6.2.2 In all non-standard drives, it is advisable to fit the drive up temporarily and check its practicability before finalizing the position of the equipment.

6.3 To transmit power in the case of flat transmission belting, the friction needed to operate the drive should be obtained by ensuring sufficient tension in the belt. In a large proportion of drives which are common, the lengths required may be calculated by the use of the following formulae:

For two-pulley open drive:

$$L = 2C + 1.57 (D + d) + \frac{(D - d)^2}{4C}$$

For two-pulley crossed-drive:

$$L = 2C + 1.57 (D + d) + \frac{(D + d)^2}{4C}$$

For quarter-turn drive:

$$L = 1.57 (D + d) + \sqrt{C^2 + D^2} + \sqrt{C^2 + d^2}$$

where

L = length of the belt,
 D = diameter of large pulley,
 d = diameter of small pulley, and
 C = centre distance.

In other cases, the belt length should be obtained by measurement round the pulleys with a steel tape, with the minimum setting where there is a take-up adjustment on the drive. Slide rail mounted motors should be moved towards the driven pulley by about three-fourths of the total travel of slide rail base before taking measurements.

6.3.1 The initial tension required in the belt is then obtained by cutting the length of belting shorter than the actual distance round the pulleys by 0.5 to 1.5 percent depending on the type of belting. The belt tightening device should permit a reduction of the nominal centre distance by 1.5 percent of the length of belt for ease of installation and an extension of the nominal centre distance by 3 percent of the length of belt for retightening of the belt.

6.3.2 Belts, after correctly tensioning, are liable to stretch up to 3 percent of their lengths and where a take-up adjustment is to be provided, it should be sufficient to take up the whole of this amount.

6.3.3 Excessive tension leads to rapid wearing out of the belt and overloading of the bearings. Insufficient tension on the other hand is the chief cause of belts failing to transmit power owing to slip which very often is overcome by the use of a belt dressing.

6.3.4 Belt dressing should not be necessary on a correctly designed and tensioned belt to transmit power.

6.4 Sometimes it is required to find the centre distance between the two pulleys when the length of the belt is known. For two-pulley open drives, the following formula may be used:

$$C = p + \sqrt{p^2 - q}$$

where

C = centre distance,

$$p = \frac{L}{4} - 0.3925 (D + d),$$

$$q = \frac{(D - d)^2}{8},$$

L = length of the belt,

D = diameter of large pulley, and

d = diameter of small pulley.

6.5 The recommendations of the fasteners manufacturers should be followed in all cases. In addition, the type of joint made should be appropriate to the type of drive and to the pulley diameters used. Large plate-type fasteners should not be used on small diameter pulleys as they will lead to the belt slip, bumpy running, and the fasteners tend to pull out of the belt.

6.5.1 An endless belt or hinged type fasteners should be used when both the surfaces of the belts come in contact with pulley faces.

7. SAFETY

7.1 The belt drives should be suitably guarded or fenced in accordance with safety requirements of the Indian Factories Act.

7.2 Whenever it is necessary to take a belt off the driving pulleys, it should be suspended from a hook so that it does not rest against any moving part of the drive. The belts should never be allowed to hang on moving shafts or against the edge of a moving pulley.

8 MAINTENANCE OF BELTING

8.1 Storage of Transmission Belting — Flat transmission belting should be stored in a cool, dry, well-ventilated stack room. Owing to the tendency for permanent set to occur when the belting is stored for a long period, the edges of the belting should be parallel with each other in a roll. The leather belts should be preserved by the application of dubbin.

8.1.1 As belting is coiled into rolls under tension, there is a tendency, especially in the case of narrow belts, for the rolls to telescope in storage. This should be avoided as the telescope section will take a permanent set and run dog-legged over the pulleys. It is, therefore, preferable for narrow belt rolls to be banded together while in storage.

8.1.2 Though not essential, it is quite a reasonable practice to lay out the belting, which has been stored for a period, flat on runners immediately prior to installation.

8.2 Cleaning of Belts

8.2.1 Leather Belts — It is recommended that the leather belts should be cleaned periodically with clean cloth or with lukewarm water. If belt drive is working in dirty conditions, then the belts may be cleaned with soap solution or in some special cases with 1 percent soda solution from all sides with the help of a brush. The belt should be dried and some acid-free leather oil should be applied to the belt (animal or vegetable oils and fats are recommended).

8.2.2 Rubber and Rubberized Belts — It is recommended that the rubber belts should be cleaned with clean cloth, lukewarm water, 1.5 percent soda solution or light detergent. After cleaning, the surface of belting shall be wiped clean and dry. Petrol, benzol or any other petroleum solvent and oils should not be used.

8.2.3 Cotton Belts — It is recommended that cotton belts should be cleaned with petrol, benzol or 1.5 percent soda solution with the help of a brush. The edges of the belt should be treated in a manner so that loose fibres do not come out. If the belt is working in dirty conditions, then the belts should be thoroughly brushed after every three months. Cotton belts should be protected, as far as possible, from oils and water.

8.2.4 Hair Belts — Hair belts should be cleaned with a soft brush periodically and be rubbed with a rag soaked in mild detergent solution, removing grease, oil, etc.

8.3 Surface and Edge Wear — Wear on the surface and edges of the belting caused by fouling against stationary objects is an extremely frequent cause of deterioration of belts.

8.3.1 Particular care should be taken on long pulley centre drives to ensure that there is a clearance on the slack side of the belt and that this does not trail either on the floor where the slack side is below or any part of the equipment, while in motion.

8.3.2 When there is shifting gear, the belt should not be left running for long periods with the moving belt edge wearing itself by contact with the edge of the fork. The design of the forks should be such that abrasion on the edge of the belt is kept to a minimum for which reason the forks constructed with rollers are generally recommended.

8.4 Inspection of Belts While Running — All running belts should be inspected regularly at intervals. Very often it is not the belt that causes early breakdown, but lack of attention. Inspection is particularly important after installation to ensure that belt tension is maintained.

8.5 Use of Belt Dressing — The use of belt dressing is closely linked with the use of leather and hair belting, which require to be lubricated to keep them supple and flexible. Dressing should be sparingly used for these two types of belting as recommended by the supplier.

8.5.1 Dressing should not be used with rubber belting as the dressing in most cases will cause the rubber belts to swell, and the frictional grip is raised to an extent when the belt starts to peel in patches and to disintegrate.

8.5.2 Belt dressing should not be used to increase the effective coefficient of friction between the belt and the pulley surface. Many dressings contain substances specially added to make belts 'stick' to the pulley.

These substances generally contain soaps and resins which increase the grip of the belt temporarily but they also form injurious crusts on the surface of the belt and ruin it.

8.5.3 The first requisite of a belt dressing, therefore, is its freedom from ingredients harmful to the belt and the second that it should serve the purpose for which it is applied, namely, to lubricate the fibres of hair and leather belting as these suffer from drying out on account of internal friction. If a belt slips, it is usually preferable to investigate the cause of slip and rectify it rather than use a dressing, as drives are not normally designed to operate with the use of dressing as a means of sustaining the necessary coefficient of friction.

8.6 Prolonged exposure to heat of rubber belts leads to the rubber overcuring and ageing prematurely. Contact with oil should also be avoided as it swells the rubber. Care should, therefore, be exercised in lubricating bearings and other parts of machines. Oil on the belt surface will also cause slip.

9. FITTING FASTENERS

9.1 The type of fastener should be selected depending upon the type of service for which the belt would be employed. There are different types of fasteners, for example, hinged (light and heavy type), plate fasteners, etc. Belt ends can also be joined together with leather laces. It is recommended that the advice of the manufacturers be sought for specific applications.

9.2 The fasteners should be fitted in the following steps:

- a) See that both ends of the belt are cut square and at right angles to the edges. The belt edges should be marked off with a square and cut along this line to a steel straight edge. See that the knife is sharp and cuts clean. Moisten the knife blade while cutting. See that the newly cut ends are clean and free from ragged cotton ends. Do not pluck the ragged cotton ends but cut them off.
- b) Take the greatest care in marking out the position of the holes for rivets, bolts, laces, etc, and use a sharp piercing tool of the correct size to make the holes.
- c) In fitting strap or plate fasteners, draw up the two ends tightly together and see that the edges are in alignment.
- d) See that the fastener, and especially the pin in the hinged joint, does not project beyond the edge of the belt, which may cause serious injuries to the operatives.
- e) The clearance between the belt and exterior objects, such as belt guides, should influence the choice of the fastener.

IS : 2122 (Part I) - 1973

- f) Certain types of fasteners, though definitely useful for leather belts, are quite unsuitable for fabric belts. Such fasteners which cannot be clinched over, or secured on both sides of the belt, should be avoided.
- g) Inspect fasteners from time to time and adjust at once, when necessary, in order to take up slack. Never refit an old fastener which has been bent or damaged.

APPENDIX A

(Clauses 0.5 and 3.1.1)

LIST OF STANDARDS PERTAINING TO ALLIED ITEMS

PULLEYS AND BELTS

- IS : 529-1959 Solid-woven impregnated cotton belting for power transmission (*revised*)
- IS : 530-1959 Solid-woven impregnated hair belting for power transmission (*revised*)
- IS : 1370-1965 Friction surface rubber transmission belting (*revised*)
- IS : 1691-1968 Cast iron and mild steel flat pulleys (*first revision*)
- IS : 2240-1962 Vegetable tanned leather belting for power transmission

BEARINGS

- IS : 2398-1967 Identification code for rolling bearings
- IS : 2399-1964 Glossary of terms relating to rolling bearings
- IS : 3090-1965 Code of practice for installation and maintenance of rolling bearings
- IS : 5669-1970 General plan of boundary dimensions for radial rolling bearings
- IS : 5692-1970 Tolerances for radial rolling bearings
- IS : 6453-1972 Technical supply conditions for rolling bearings

GENERAL

- IS : 2048-1962 Parallel keys and keyways
- IS : 2291-1963 Tangential keys and keyways
- IS : 2292-1963 Taper keys and keyways
- IS : 2293-1963 Gib-head keys and keyways
- IS : 2294-1963 Woodruff keys and keyslots
- IS : 3688-1966 Dimensions for shaft ends

BUREAU OF INDIAN STANDARDS

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53/5, Ward No. 29, R.G. Barua Road, 5th Byelane, GUWAHATI 781003	3 31 77
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